tially free from any cubic entities and have an optical absorption coefficient of about 2 cm^{-1} and less at wavelengths between about 385 nanometers and about 750 nanometers. An ammonothermally-grown gallium nitride crystal may comprise a crystalline substrate member having a length greater than about 5 millimeters, have a wurtzite structure and be substantially free of other crystal structures, the other structures being less than about 0.1% in volume in reference to the substantially wurtzite structure, an impurity concentration greater than 10^{14} cm^{-1}, greater than 10^{15} cm^{-1}, or greater than 10^{16} cm^{-1} of at least one of Li, Na, K, Rb, Cs, Mg, Ca, F, and Cl, and an optical absorption coefficient of about 2 cm^{-1} and less at wavelengths between about 385 nanometers and about 750 nanometers. The ammonothermally-grown gallium nitride crystal may be semi-insulating, with a resistivity greater than 10^7 Ω-cm. The ammonothermally-grown gallium nitride crystal may be an n-type semiconductor, with a carrier concentration n between about 10^{16} cm^{-3} and 10^{20} cm^{-3} and a carrier mobility η, in units of centimeters squared per volt-second, such that the logarithm to the base 10 of η is greater than about $-0.018557\ n^3+1.0671\ n^2-20.599\ n+135.49$. The ammonothermally-grown gallium nitride crystal may be a p-type semiconductor, with a carrier concentration n between about 10^{16} cm^{-3} and 10^{20} cm^{-3} and a carrier mobility η, in units of centimeters squared per volt-second, such that the logarithm to the base 10 of η is greater than about $-0.6546\ n+12.809$.

By growing for a suitable period of time, the ammonothermally-grown crystalline group III metal nitride may have a thickness of greater than about 1 millimeter and a length, or diameter, greater than about 20 millimeters. In a preferred embodiment, the length is greater than about 50 millimeters or greater than about 100 millimeters. The crystalline group III nitride may be characterized by crystallographic radius of curvature of greater than 100 meters, greater than 1000 meter, or be greater than can be readily measured (infinite). After growth, the ammonothermally-grown crystalline group III metal nitride may be sliced, polished, and chemical-mechanically polished according to methods that are known in the art to form one or more wafers or crystalline substrate members. In a preferred embodiment, the root-mean-square surface roughness of the at least one wafer or crystalline substrate member is less than about one nanometer, for example, as measured by atomic force microscopy over an area of at least about 10 micrometers by 10 micrometers.

In another embodiment, the polycrystalline group III metal nitride is used as a source material for flux growth of at least one group III metal nitride single crystal, as described in U.S. Pat. No. 7,063,741 and in U.S. Patent Application 2006/0037529, each of which are hereby incorporated by reference in their entirety. The polycrystalline group III metal nitride and at least one flux are placed in a crucible and inserted into a furnace. The furnace is heated and the polycrystalline group III metal nitride is processed in a molten flux at a temperature greater than about 400 degrees Celsius and a pressure greater than about one atmosphere, during which at least a portion of the polycrystalline group III metal nitride is etched away and recrystallized onto at least one group III nitride crystal. Residual getter in the polycrystalline group III metal nitride is released into solution gradually, as the polycrystalline group III metal nitride is etched. Once in solution, the getter may react to form a getter metal nitride, amide, or halide. The getter may also be chemically bound to oxygen. The getter may remove residual oxygen in the molten flux, enabling growth of group III nitride single crystals with improved purity.

While the above is a full description of the specific embodiments, various modifications, alternative constructions and equivalents may be used. Therefore, the above description and illustrations should not be taken as limiting the scope of the present invention which is defined by the appended claims.

What is claimed is:

1. A polycrystalline gallium-containing group III metal nitride material, comprising:

a plurality of grains of a crystalline gallium-containing group III metal nitride;

the plurality of grains having an average grain size in a range of from about 10 nanometers to about 1 millimeter and defining a plurality of grain boundaries; and

the crystalline gallium-containing group III metal nitride having:

an atomic fraction of a gallium-containing group III metal in a range of from about 0.49 to about 0.55, the metal being selected from at least one of aluminum, indium, and gallium; and

an oxygen content in the form of a gallium-containing group III metal oxide or a substitutional impurity within the crystalline gallium-containing group III metal nitride less than about 10 parts per million (ppm); and

a plurality of inclusions within at least one of the plurality of grain boundaries and the plurality of grains, the plurality of inclusions comprising a getter, the getter constituting a distinct phase from the crystalline gallium-containing group III metal nitride and being incorporated into the polycrystalline gallium-containing group III metal nitride material at a level greater than about 200 parts per million.

2. The material as defined in claim **1**, wherein the crystalline gallium-containing group III metal nitride has a porosity in volume fraction in a range of from about 0.1 percent to about 30 percent by volume; and an apparent density in a range of from about 70 percent to about 99.8 percent of a theoretical density value.

3. The material as defined in claim **1**, wherein the getter comprises a metal.

4. The material as defined in claim **1**, wherein the getter comprises at least one of alkaline earth metals, scandium, titanium, vanadium, chromium, yttrium, zirconium, niobium, the rare earth metals, hafnium, tantalum, tungsten, a nitride of any of the foregoing, and a halide of any of the foregoing.

5. The material as defined in claim **1**, wherein the getter is present at a level greater than about 0.1% by weight.

6. The material as defined in claim **1**, wherein the oxygen content present as a gallium-containing group III metal oxide or as a substitutional impurity within the crystalline gallium-containing group III metal nitride is less than about 3 parts per million (ppm).

7. The material as defined in claim **1**, wherein the oxygen content present as a gallium-containing group III metal oxide or as a substitutional impurity within the crystalline gallium-containing group III metal is less than about 1 part per million (ppm).

8. The material as defined in claim **1**, wherein the plurality of grains is characterized by a density from about 100 per cubic centimeter to about 10,000 per cubic centimeter.

9. The material as defined in claim **1**, wherein the polycrystalline gallium-containing group III metal nitride material has a porosity from about 0.1 percent to about 10 percent by volume.